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Schaeff

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[54] **MULTI-BUCKET EXCAVATING MACHINE**

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[51] **Int. Cl.** **E02f 5/06**

[58] **Field of Search** ..... 37/191-192, 37/90, 83-89, DIG. 2

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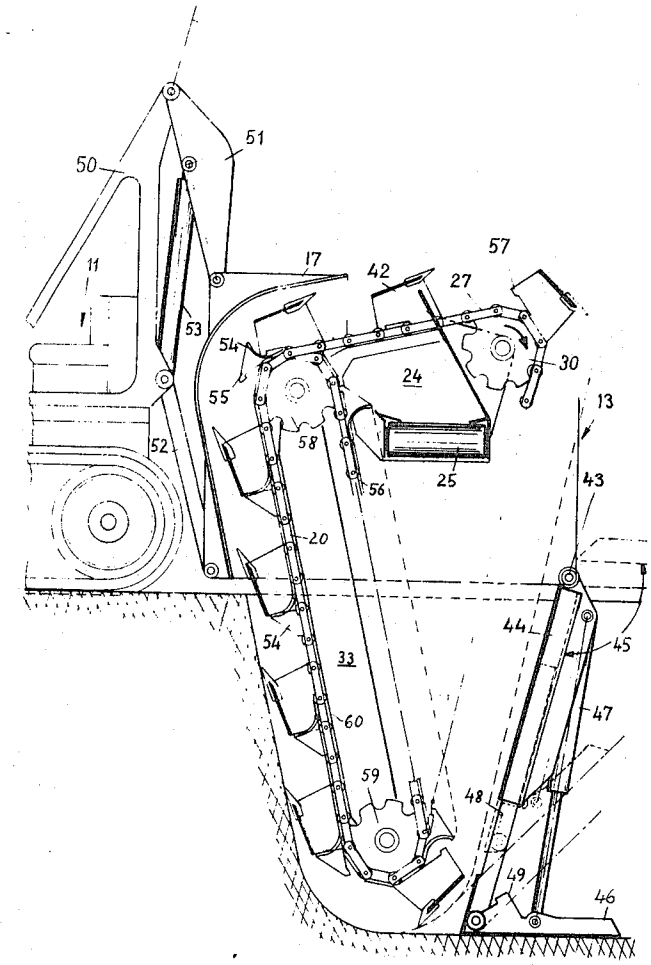
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Assistant Examiner—Clifford D. Crowder
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[57] **ABSTRACT**

A trench-digging machine for attachment to a general-purpose carrier vehicle, the vertically moveable frame of the machine enclosing an upright bucket conveyor whose elements are carried by two separate endless chain pairs which move upwardly in a parallel path and separate on their upper reversal, the outer chain pair carrying cutting yokes, while the inner one carries buckets. The buckets may move independently at a higher speed than the cutting yokes, or they may be synchronized at the same pitch, so that the cutting yokes and the partial buckets on the inner chain pair form composite buckets which open conveniently for emptying, as the chain paths separate. The machine may further include a drag support with a hydraulically controlled glide shoe pressing against the bottom of the trench to stabilize the carrier vehicle.

16 Claims, 4 Drawing Figures



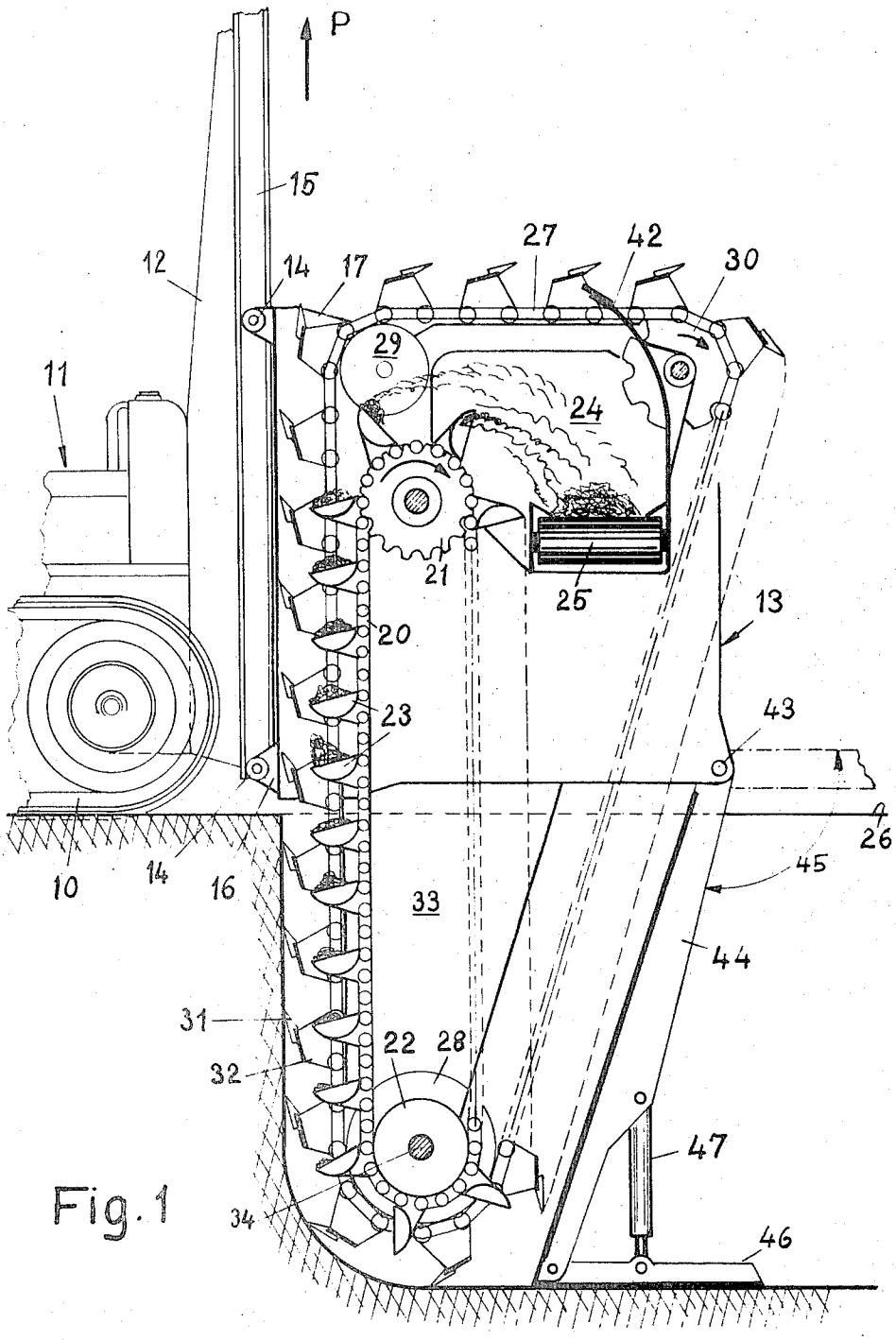

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Fig. 1

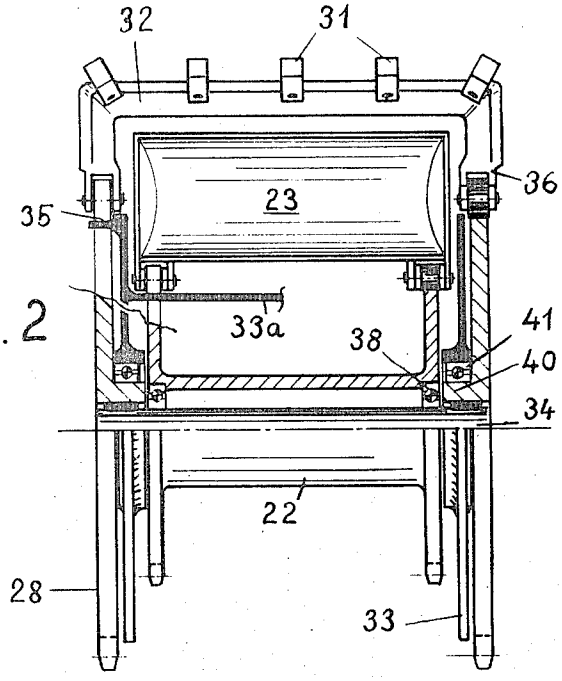

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Fig. 2

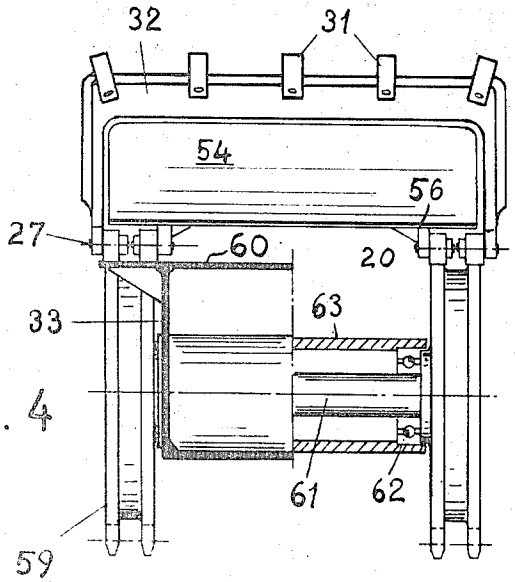

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Fig. 4

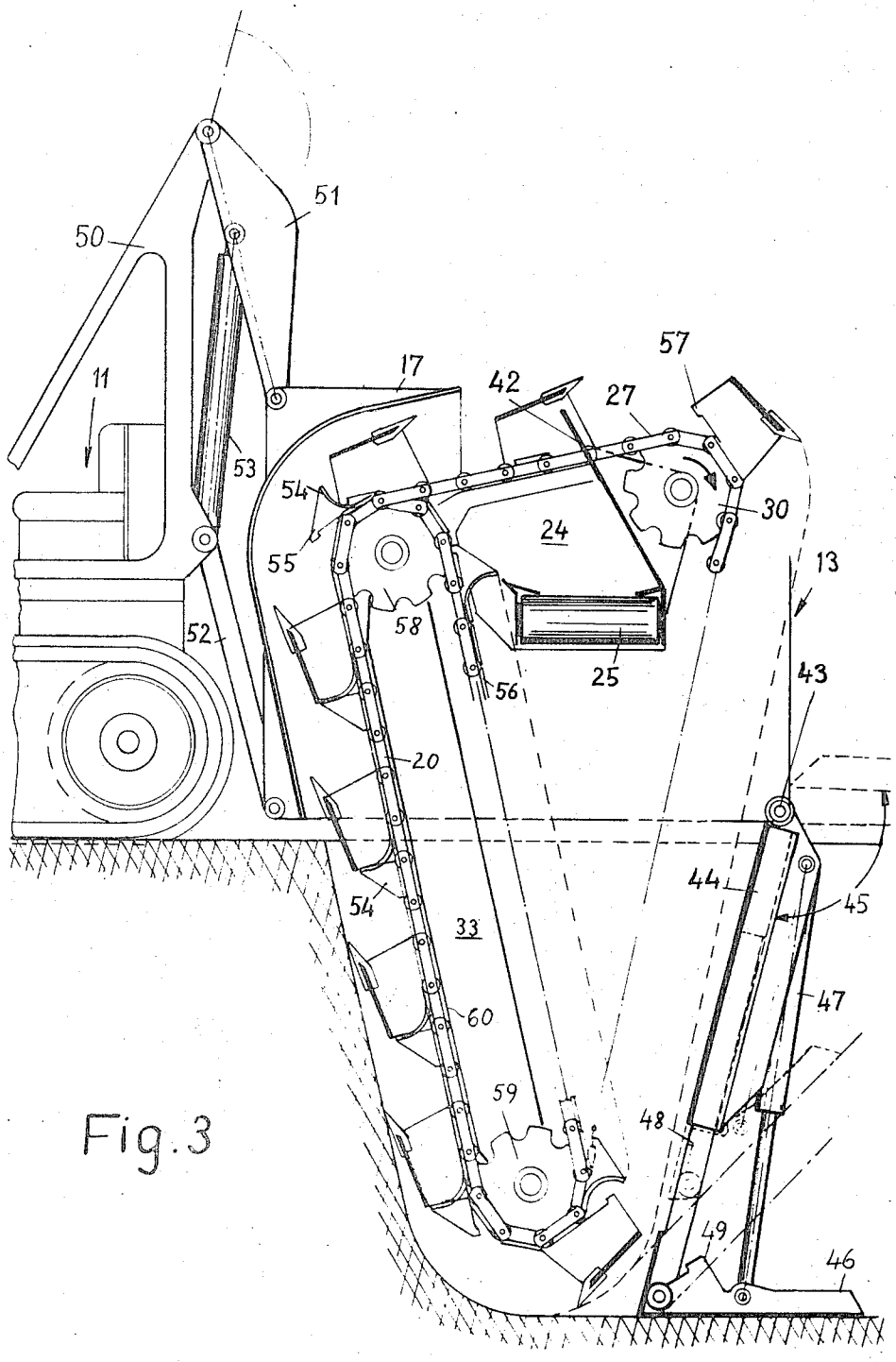

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Fig. 3

MULTI-BUCKET EXCAVATING MACHINE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to mechanically operated excavating machinery, and in particular to trench-digging machines which are attached to a carrier vehicle and which, within a vertically movable frame, comprise a vertical bucket conveyor, a transverse take-off conveyor, and a drag support and glide shoe.

2. Description of the Prior Art

The prior art in the field of trench-digging machinery includes bucket chain devices for the excavation of trenches (so-called deep-trenching machines) which have one-piece buckets. In some cases, the "bucket train" i.e., the frame and guides in which the bucket chain travels, is pivotably supported on the carrier vehicle in such a manner that the adjustment of the digging depth is obtained by changing the angle of the frame from a horizontal alignment to an angle of approximately 30°–40° downward. In this case, it is not possible to obtain great digging depths, because the excavated material would not remain on the relatively flat buckets, falling instead through the chain before the point of trnasfer, and thus rendering the efficiency of excavation uneconomical. The digging depth in this case can only be increased by extending the bucket train downwardly. However, because the train is inclined, only a portion of this extension would be useful in additional depth, while the rearward component of the extension would represent an unfavorable shift of the center of gravity of the machine and of the pressure distribution between the vehicle and the ground. For this reason, trench-digging machines of this kind are generally special-purpose machines carried by a tracked vehicle, whereby the frame of the machine is arranged as far inside between the two tracks in the vehicle chassis as possible, the drive unit being arranged forward above the vehicle.

Other known bucket chain excavators have openable buckets where a removable bottom is arranged in the bucket itself or in the bucket chain. The mechanisms employed for these openable buckets create a pivoting action on the bucket bottom for emptying and a resetting action of the bucket bottom after emptying. Such mechanisms are both complex and expensive, and they are subject to considerable wear.

SUMMARY OF THE INVENTION

It is a primary objective of the present invention to provide a trench-digging machine which does not necessarily require a special-purpose, counterweighted vehicle for its attachment, but which may be mounted with simple means onto an ordinary carrier vehicle, such as a wheeled or tracked tractor, without thereby being unduly restricted as far as digging depth and digging efficiency are concerned.

The invention proposes to attain this objective by suggesting a trench-digging machine of the kind mentioned, where the vertical bucket conveyor includes two parallel endless chain pairs of which the one carries generally flat buckets which include a retaining wall on at least the side facing toward the chain and of which the other chain pair carries a series of cutting yokes which surround the carrier buckets to retain the loose material thereon and which move away from the buckets at the point of material transfer.

This approach makes it possible to use an approximately vertical bucket train in a vertical work area, so that the overhang of the machine towards the rear is kept to a minimum. Thus, the weight proper of the carrier vehicle, which need not be specially designed for such a trench-digging attachment, will be sufficient to keep the center of gravity of the complete assembly on a line which still permits digging operations without the danger of the vehicle being upended under elevated digging forces. The favorable vertical working area and the minimal rear overhang of the digging attachment are primarily the result of a novel arrangement which proposes two independently supported chain pairs, of which one carries the cutting yokes and the other carries conveyor buckets or plates which, together with the cutting yokes, form complete carrier buckets. In the transfer area these buckets are conveniently and safely opened by separating the paths of the two chain pairs. A further advantage of the solution suggested by the invention resides in the fact that it permits initial digging penetration in a vertical direction, so that previously necessary sloping sections at the beginning of trenches are eliminated. This machine thus also permits the digging of holes for the insertion of poles and the like.

According to one embodiment of the invention, the conveyor members are closed off on their sides facing the chain pairs by providing articulated plates between the chain strands. In the digging area, these conveyor members and the adjacently moving cutting yokes follow the same path on an identical pitch so as to form a vertically moving bucket chain with composite buckets. Thus, in its forward digging area this arrangement resembles a conventional bucket chain machine, the main difference being that in the machine of the invention the buckets consist of several independent elements which, by virtue of their convenient separation and recombination, permit a higher digging output with an improved efficiency, because this kind of conveyor can reach deeper into the ground than known machines and because its buckets can be filled more completely and emptied quickly and safely.

According to another embodiment of the invention, the conveyor buckets are arranged approximately perpendicularly to their chain pair in the form of shallow buckets, these buckets having a smaller pitch than the associated cutting yokes. This arrangement permits an increased digging output because, with it, the speed of the short-pitch bucket conveyor can be increased considerably over the speed of the cutting yokes, so that a greater amount of material can be carried away by the bucket conveyor. This arrangement has the great advantage that it permits the independent adjustment of the cutting speed on the cutting yokes in response to the type and density of material to be cut, thereby minimizing the wear on the cutters, especially when hard materials are cut at high speeds. This independence of speed adjustment permits the setting of a bucket conveyor speed which is optimal for the filling of the bucket and for the material transfer.

A further suggestion of the invention relates to a glide shoe which is dragged over the bottom of the trench on a drag support and which is pushed downward by means of a hydraulic cylinder whose pressure is derived from the hydraulic working pressure of the drive for the cutting yoke chain. Thus, the pressure between the glide shoe and the trench bottom is always

kept proportional to the cutting forces created on the front end of the machine. This arrangement completely eliminates any tendency of the carrier vehicle to be upended, even under very high digging forces, because the counter-moment created by the drag support and glide shoe stabilizes the trench-digging machine at all times inside the trench itself. Further specific characteristics are listed in the detailed description and in the appended claims following below.

BRIEF DESCRIPTION OF THE DRAWINGS

Further special features and advantages of the invention will become apparent from the description following below, when taken together with the accompanying drawings which illustrate, by way of examples, several embodiments of the invention, represented in the various figures as follows:

FIG. 1 shows an elevational side view, partially in section, of a trench-digging machine embodying the invention;

FIG. 2 represents a constructional detail of the embodiment of FIG. 1 shown in a horizontal cross section through the lower shaft of the chain drive;

FIG. 3 shows, in a representation similar to FIG. 1, a second embodiment of the invention; and

FIG. 4 represents a constructional detail of the embodiment of FIG. 3, such as a horizontal cross section through the area of the lower shaft of the chain drive.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As illustrated in FIG. 1, a trench-digging machine embodying the invention may be attached to a carrier vehicle 11 which has drive tracks 10 and which includes a vertical guide frame 12 on which the main frame 13 of the trench-digging machine is movably guided by means of rollers 14 which engage two vertical guide rails 15 on the frame 12. The trench-digging machine can thus be vertically adjusted in the direction of arrow P, by means of a motor-driven cable winch (not shown), the downward advance being provided by the weight of the trench-digging machine itself. The cable winch includes blocking means which hold the main frame in any desired vertical position. The guide rollers 15 are mounted at the outer end of support brackets 16 which are attached to the vertical caisson 17 which guides the digging elements.

In the main frame 13 are mounted two chain drives, a first one including a chain pair 20 which runs over an upper driven sprocket 21 and a lower free-running sprocket 22 which is arranged vertically below sprocket 21. On the chain pair 20 are mounted conveyor elements in the form of shallow buckets 23 which follow one another at a preferably short pitch and which are slightly inclined forwardly, so that even tacky material is easily removed from the buckets at the point where they are to be emptied. Behind the upper reversal path of the buckets around the sprocket 21 is arranged an opening in the frame 13 through which a transversely oriented take-off conveyor 25 extends into the main frame 13. In the example shown in FIG. 1, this take-off conveyor 25 is arranged at a considerable height above the ground level 26 in order to permit discharge of the excavated material from above onto a continuous pile of excavated material. It is of course also possible to extend the horizontal take-off conveyor 25 by means of an upwardly inclined elevator conveyor, at the upper end of which the material is discharged, in which case the upper portion of the main frame 13 may be arranged at a correspondingly lower level relative to the ground level 26.

Also arranged inside the main frame 13 is a second chain pair 27 which runs approximately parallel to the first chain pair 20 in the area of the vertical forward end of the trench-digging machine. This chain pair 27 runs around a freely rotating lower sprocket 28, a first upper sprocket 29 which is freely rotating, and a second upper sprocket 30 which is driven and which is arranged behind the sprocket 29 at about the same level. The chain pair 27 carries a succession of cutting yokes 32 equipped with cutters 31 at their forward end. The cutting yokes 32 surround the conveyor buckets 23 with a predetermined clearance. In addition to their cutters 31, the cutting yokes 32 have a generally sharp upper edge which opens away from the path of the buckets so that the material which has been loosened by the cutters 31 is guided into the conveyor buckets 23. In FIG. 1, the upper sprocket 29 for the chain pair 27 is shown to be arranged above and at a distance from the sprocket 21 of the chain pair 20, in order to better represent the independence of the two chain pairs and of the conveyor elements attached to them. The drawing also implies, through the material transfer path shown, that the speed of the conveyor buckets 23 is a considerable one, so that the centrifugal forces acting on the loose material assist in the material transfer to the take-off conveyor 25. However, it may be preferable to arrange the axis for the upper sprocket 29 so as to coincide with the axis of sprocket 21, in order to reduce the overall height of the main frame 13 and to save manufacturing costs. In this case, the size ratio between these sprockets 21 and 29 would be the same as that between the lower sprockets 22 and 28, or one may even choose to make all four sprockets of the same diameter. Because the upper sprocket 21 is supplying the drive for the chain pair 20, it is necessary to arrange the upper sprocket 29 to be freely rotatable on the driven shaft of sprocket 21.

In FIG. 2 are illustrated several constructional details of that portion of the conveyor train which penetrates into the trench, the drawing showing a horizontal cross section in the area of the lower sprockets 22 and 28. The stationary parts of the conveyor train include, as part of the main frame 13, two parallel face plates 33 arranged at a horizontal distance from one another, the face plates 33 being linked together by a transverse plate 33a attached thereto by weldments so as to form a rigid caisson which supports the conveyor. The transverse shaft 34 which carries the double sprockets 22 and 28 is arranged in the lower end of the caisson profile. The two face plates 33 carry on their forward edges guide profiles 35 which extend between the lower sprocket 28 and the upper sprocket 29 and against which the chain pair 27 is supported horizontally by its rollers, thereby opposing the back pressures created by the excavating operation. Thus, the cutting forces acting on the cutting yokes 32 and on their cutters 31 are directly supported on the caisson profile. The lateral portions 26 of the cutting yokes 32 are so designed that they form links in the chain pair 27.

As is also shown in FIG. 2, the double sprocket 22 is journalled on the horizontal shaft 34 by means of ball bearings 38 which are arranged on the inside of the face plates 33 of the caisson profile. The double

sprocket 28, on the other hand, is composed of two separate sprockets which are arranged outside the face plates 33, being directly supported in the latter by means of ball bearings 41, these outer sprockets in turn carrying the horizontal shaft 34 to which they are locked by means of keys.

The two chain pairs 20 and 27 are individually driven by means of their upper sprockets 21 and 30, respectively, which are arranged in the upper part of the main frame 13, the speed of the chain pairs 20 and 27 being adjustable independently and continuously. The outer chain pair 27 for the cutting yokes is driven on its rear sprocket 30 in order to maintain tension on the horizontal chain strand between the upper sprockets 28 and 30. This tension is necessary to assure a safe operation of the wiper plate 42 over which the cutting yokes 32 pass at a given distance so that the yokes are cleared of tacky material. The wiper plate 42 guides this material onto the take-off conveyor 25 and at the same time closes off the opening 24 in the main frame 13 against the rear.

To the rear portion of main frame 13 is pivotably attached at 43, a drag support 44 which is adjustable, for example, by means of a hydraulic cylinder (not shown), within the angular region 45, which is greater than 90° and which includes a lower working position and an upper retracted position indicated by broken lines. The drag support 44 must be pivoted into its retracted position when the trench digging machine is initially penetrating into the ground for the start of a trench or for the digging of a hole. After the desired trench depth has been reached and a short trench has been excavated, the drag support 44 is pivoted downwardly into its working position so that the glide shoe 46 which is attached to the lower end of the support 44 contacts the bottom of the trench, the glide shoe 46 being pressed downwardly by means of a hydraulic cylinder 47.

A second embodiment as illustrated in FIGS. 3 and 4 suggests a trench-digging machine which is again attached to a carrier vehicle 11 by means of a mounting frame 50. The connection between the trench-digging machine and the mounting frame 50 is constituted by an adjustable linkage. The latter includes two parallel links 51 and 52 and a hydraulic cylinder 53 through whose operation the machine can be moved up and down along an arcuate path, while the machine alignment is maintained at a constant angle. The mounting frame 50 may in addition be arranged so as to permit pivoting of the machine into a horizontal position, when the elevated trench-digging machine on the carrier vehicle is to be moved under low clearances, such as underpasses, building entrances and the like. In this case, the trench-digging machine is pivoted by about 90° into a horizontal alignment so that the bucket conveyor train comes to extend approximately horizontally from the carrier vehicle. A similar arrangement may also be provided on the vertical guide frame 12 of the embodiment illustrated in FIG. 1.

The embodiment of FIG. 3 again includes two chain pairs 20 and 27 for the bucket conveyor, the conveyor buckets attached to the chain pair 20 being composed of simple curved plates 54 which form only the rear wall and the bottom of each conveyor bucket, with a gussett 55 on the chain 20 supporting each bucket bottom against the next-following chain link. The bucket plates 54 are connected on their side facing toward the chain to articulated plates 56 which extend between the two chain strands so as to prevent the passage of loose material through the chain to the inside of the machine. The second chain pair 27 has the same longitudinal pitch as the first chain pair 20 and carries independently supported but correspondingly positioned cutting yokes 32 which move in unison with the bucket bottoms on chain 20 so as to form the forward and lateral wall portions of complete buckets in the upwardly moving strand of the chain conveyor. Thus, the two chain pairs 20 and 27 with their attached bucket elements 54 and 32 form composite buckets which are guided and supported against the cutting forces during their upward motion. The cutting yokes 32 may also be provided with support brackets 57 which engage adjacent chain links to give the composite buckets additional rigidity and resistance against the cutting pressures.

Unlike the previously described embodiment of FIGS. 1 and 2, the embodiment of FIGS. 3 and 4 suggests that the two chain pairs 20 and 27 are guided over upper and lower sprockets 58 and 59, respectively, which have the same pitch and diameter. In this case, the inner chain pair 20 which carries the bottom portions of the buckets does not require a separate drive, but derives its movement from the outer chain pair 27 which is driven by the rear sprocket 30, the parallel portions of the chain pairs 20 and 27 running over one set of double twin sprockets 58 and 59 (FIG. 4). FIG. 3 shows how, in their path around the upper sprocket 58, the inner and outer chain pairs are separated from one another so that the cutting yokes 32 move horizontally away from the bucket plates 54 as the latter move downwardly, thereby emptying their contents onto the take-off conveyor 25 arranged in a manner similar to that shown in FIG. 1. This positive, linkage-free opening of the buckets assures trouble-free operation at high speeds and at a minimum of wear. A wiper plate 42 is again arranged between the horizontal path of the cutting yokes 32 and the take-off conveyor 25 to remove any tacky material remaining on the yokes 32. In the partial horizontal cross section through the lower sprocket as shown in FIG. 4, it can be seen that the simplification of the two chain pairs 20 and 27 also simplifies the supporting caisson profile, which latter includes a continuous guide plate 60 at its forward side serving as a support for the rollers of the chains 20 and 27. The double sprockets 58 and 59 include two twin sprockets on each side of the caisson profile, a shaft 61 forming a rigid connection between the two thin sprockets and journalled by means of ball bearings 62, the latter being mounted inside a connecting sleeve 63 between the lateral face plates 33 of the caisson profile.

The embodiment of FIG. 3 is again provided with a drag support 44 which is pivotally connected to the rear portion of the main frame 13 at a pivot 43. The drag support in this case includes in its lower portion a vertical telescopic extension 48, to the lower end of which is attached one side of the glide shoe 46. A hydraulic cylinder 47 forms a link between the center of the glide shoe 46 and the upper end of the drag support 44, thereby permitting the application of downward pressure to the glide shoe 46. The hydraulic cylinder 47 can be locked in position. In order to extend the cylinder 47, its hydraulic pressure supply is connected in parallel with the pressure supply for the chain drive on the chain sprocket 30. At the beginning of a digging operation it is necessary to retract the cylinder 47 so

that the glide shoe **46** is pivoted upwardly until the stop **49** comes to rest against the vertical extension **48** of the drag support **44**. Further retraction of the cylinder causes the glide shoe and the extension **48** to be pulled upwardly into the drag support into an end position shown by dotted lines. The cylinder **47** is locked in this position and the entire drag support and glide shoe assembly can now be pivoted upwardly around the angle **45**. During the beginning of a digging operation, the drag support and glide shoe may be maintained in their retracted, pivoted position (dotted line position), the glide shoe thus forming a support which guides the machine downwardly into the trench. After the desired trench depth has been obtained, and the forward motion of the machine has been initiated, the cylinder **47** is pressurized so that the glide shoe **46** is pushed against the trench bottom with a force which is proportional to the excavating forces created at the forward end of the bucket conveyor.

The previously described operation of the glide shoe and the operative connection between the hydraulic chain drive and the pressure in the cylinder **47** is necessary, or at least advisable, in order to prevent any upending of the carrier vehicle. It should be noted however, that such an arrangement and control of the glide shoe to create a compensatory support may also be advantageously applied to other types of trench-digging machines, especially those of the bucket conveyor type, the provision of such a drag support and glide shoe making possible the elimination of any additional counterweights otherwise necessary on the carrier vehicle to counteract the weight and the excavating forces of the overhanging trench-digging machine.

What is claimed is:

1. A multi-bucket excavating machine comprising:

a. a main frame adapted to be carried by a vehicle, and a bucket conveyor and a drive for said bucket conveyor in said frame;

b. an endless inner chain pair carrying bucket elements guided over first upper and lower sprockets of said bucket conveyor;

c. an endless outer chain pair carrying a plurality of cutting elements guided over second upper and lower sprockets of said bucket conveyor;

d. said sprockets and chain pairs being so arranged that both chain pairs move upwardly in parallel relationship on one side of said bucket conveyor;

e. said bucket elements having a shallow configuration and said cutting elements having earth retaining frames of such size as to enclose three sides of said bucket elements to retain material in said buckets;

f. said sprockets and chain pairs being so arranged that, at one point in the paths of said chains, said outer chain pair moves away from said inner chain pair thereby interrupting the material retaining action of the cutting elements and permitting rapid and complete discharge of material from said buckets.

2. A multi-bucket excavating machine as defined in claim **1**, including attachment means for the main frame, said attachment means including: an upwardly extendimg guide profile attachable to the carrier vehicle; rollers on the main frame which engage the guide profile so as to permit upward and downward movement of the main frame relative to the carrier vehicle; and drive means capable of raising and lowering the main frame.

3. A multi-bucket excavating machine as defined in claim **1**, including attachment means for the main frame, said attachment means including: a double linkage for the attachment of the main frame to the carrier vehicle in such a way that the upward and downward adjustment of the main frame follows an arcuate path, the orientation of the main frame remaining substantially unchanged in all positions; and drive means capable of moving the double linkage to raise and lower the main frame.

4. A multi-bucket excavating machine as defined in claim **1**, wherein

the inner chain pair runs over a lower double sprocket and an upper double sprocket in a flat, generally upright loop, while the outer chain pair runs over a lower double sprocket and over two upper double sprockets, whose axes are spaced a horizontal distance from one another, the outer chain pair thus running in a triangular loop, with a rearwardly running upper chain strand between the front and rear upper sprockets;

the machine further comprising a transversely oriented takeoff conveyor arranged behind the upper double sprocket for the inner chain pair and below the rearwardly running strand of the outer chain pair.

5. A multi-bucket excavating machine as defined in claim **4**, wherein

the outer chain pair receives its drive from the rear upper sprocket, thereby maintaining tension on the rearwardly running chain strand;

the takeoff conveyor including an upwardly extending wiper plate which extends into the vicinity of the path of the cutting elements on the rearwardly running chain strand so as to remove residual material therefrom.

6. A multi-bucket excavating machine as defined in claim **4**, wherein

the lower double sprockets of the inner and outer chain pairs have a common axis.

7. A multi-bucket excavating machine as defined in claim **6**, wherein

the upper double sprocket of the inner chain pair and the upper forward double sprocket of the outer chain pair have a common axis.

8. A multi-bucket excavating machine as defined in claim **7**, wherein

the inner and outer chain pairs have the same chain pitch, running side-by-side over upper and lower double twin sprockets, whereby one chain pair drives the other synchronously.

9. A multi-bucket excavating machine as defined in claim **8**, wherein

the cutting elements attached to the outer chain pair and the bucket elements attached to the synchronously moving inner chain pair have the same spacing on their chains, the respective upward paths of the cutting elements and of the bucket elements being so arranged that each cutting element also forms a retaining wall portion cooperating with an adjacent bucket element to form a composite bucket, these composite buckets being opened when the cutting elements are separated from the bucket elements, as the outer chain pair moves

away from the inner chain pair during their movement around the upper double sprockets.

10. A multi-bucket excavating machine as defined in claim **9**, wherein

each bucket element includes a generally perpendicularly extending plate to form the bottom of a composite bucket, the space between the parallel strands of the inner chain pair being closed by articulated plates which also form rear retaining walls for the composite buckets; and wherein

each cutting element surrounds its adjacent bucket element on three sides in the form of a yoke, thereby forming a three-sided removable retaining wall of the composite bucket.

11. A multi-bucket excavating machine as defined in claim **6**, wherein

the main frame includes a rigid caisson profile extending inside the bucket conveyor between the lower and upper double sprockets of the two chain pairs, the caisson profile including at its forward side guide profiles against which the upwardly moving strands of the inner and outer chain pairs are movably supported so that the cutting elements are pressed forward against the material to be excavated, while the bucket elements are maintained at a fixed horizontal distance behind the cutting elements.

12. A multi-bucket excavating machine as defined in claim **4**, wherein

the inner and outer chain pairs of the bucket conveyor are arranged to be driven independently from one another;

the bucket conveyor drive further inclduing means for independently adjusting the speed of the inner chain pair and of the outer chain pair.

13. A multi-bucket excavating machine as defined in claim **12**, wherein

the outer chain pair runs at a faster speed than the inner chain pair, the cutting elements attached to the outer chain pair being spaced further from one another than the bucket elements attached to the inner chain pair; and wherein

the bucket elements extend approximately perpendicularly from the inner chain strand.

14. A multi-bucket excavating machine as defined in claim **1**, further comprising

a drag support pivotably attached to the rear portion of the main frame, with a glide shoe mounted to the lower end of the drag support, the glide shoe supporting the main frame against the bottom of the trench, the drag support being pivotable around its attachment point on the main frame between a downward working position behind the descending strands of the bucket conveyor and a retracted rearward position above the trench level.

15. The machine as defined in claim **14**, wherein

the glide shoe is upwardly and downwardly movable relative to the drag support, the latter further including means for controlling the position of the glide shoe relative to the drag support and for applying downward pressure to the glide shoe, the controlling means including means for exerting downward pressure on the glide shoe proportional to the drive torque created on the outer chain pair of the bucket conveyor under working conditions.

16. A multi-bucket excavating machine comprising:

a. a frame adapted to be carried by a vehicle;

b. a plurality of buckets and cutting elements guided about said frame, said cutting elements being powered by a hydraulic drive;

c. a drag support pivotally attached to said frame for movement about a horizontal axis;

d. a glide shoe pivotally mounted to said drag support and movable by a hydraulic cylinder;

e. said hydraulic cylinder being connected in parallel with said hydraulic drive to thereby exert on the glide shoe a force proportional to the digging forces on said cutting elements.

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